National Data Buoy Center (NDBC) Processing, Display, and Observation of Near-Bottom Currents Acquired by Oil and Gas Companies in the Northern Gulf of Mexico

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Abstract - **Under a Notice to Lessees (NTL No. 2005-G05) issued by the Minerals Management Service in April 2005, oil companies operating in the northern Gulf of Mexico in waters deeper than 400 meters are required to collect current profile data to a depth of 1000 meters. These data provide estimates of strong ocean currents, which may affect extreme loads, structural failure, and daily operations on the oil platforms and drilling rigs. Real-time data from near the surface to 1000 meters are reported every 20 minutes to the National Data Buoy Center (NDBC) and displayed on their public website. The oil and gas companies must also measure near-bottom currents at sites deeper than 1100 meters and recover and report these data at least every six months. These delayed-mode data are the subject of this effort.**

NDBC began accepting real-time current profile data in April 2005 and implemented real-time quality control of the data in March 2006 [1]. In August 2006, NDBC received four files containing the near-bottom, delayed-mode data. The data were processed through the same quality control algorithms and stored along with previously processed near-surface data. Since that time eighty-four additional data sets have been received and processed through the quality control algorithms at NDBC. Tables of these data with quality control flags and current velocity plots with depth are available to the general public on the NDBC website.

One of the first delayed-mode data sets was collected from the Na Kika platform, approximately 100 kilometers south-east of the Mississippi River delta, during the active Hurricane season of 2005. The data from August 2005 showed greater than 0.30 cm/s currents at depths greater than 1900 meters to the right of the path of Hurricane Katrina. The currents rotated clockwise in the bottom waters at a period less than 24 hours and decayed over a period of nearly ten days. Although Hurricane Rita passed 360 kilometers to the southwest of the Na Kika platform in late September 2005, the bottom waters were impacted by the passage. The currents were not as strong as those related to Hurricane Katrina, but they were noticeable and lasted for several days. There are no near-surface data sets to corroborate these data because the platforms were evacuated due to the hurricanes. These results indicate a basin-wide response to these two strong hurricanes.

I. INTRODUCTION

The Loop Current and associated Loop Eddies have a large impact on the oil industry in the Gulf of Mexico. Strong ocean currents affect extreme loads, structural failure, and daily operations on the drilling rigs and production platforms in the northern Gulf of Mexico. Estimates of strong ocean currents in the northern Gulf of Mexico are therefore required to support oil platforms and drilling rigs. The National Data Buoy Center (NDBC) receives, processes, quality controls, and archives current profile data collected by the oil and gas industry in the Northern Gulf of Mexico under a Minerals Management Service (MMS) Notice to Lessees (NTL No. 2005-G05). The display of the data as stick plots, provide an opportunity to observe several ocean phenomena. Loop Eddies cause a rotation of the currents as they move past the stationary platforms and rigs. The current speeds often exceed 100 cm/s in the Loop Eddies. High current speeds are also observed at depth (fig. 1). Tidal motion is observed as complete rotations and as modification of larger current features. Wavelike features that move up and down in the water column are thought to indicate the existence of topographic Rossby Waves. Additionally, the data stored on the website are being used in comparisons to ocean forecasts in the Gulf of Mexico [2]

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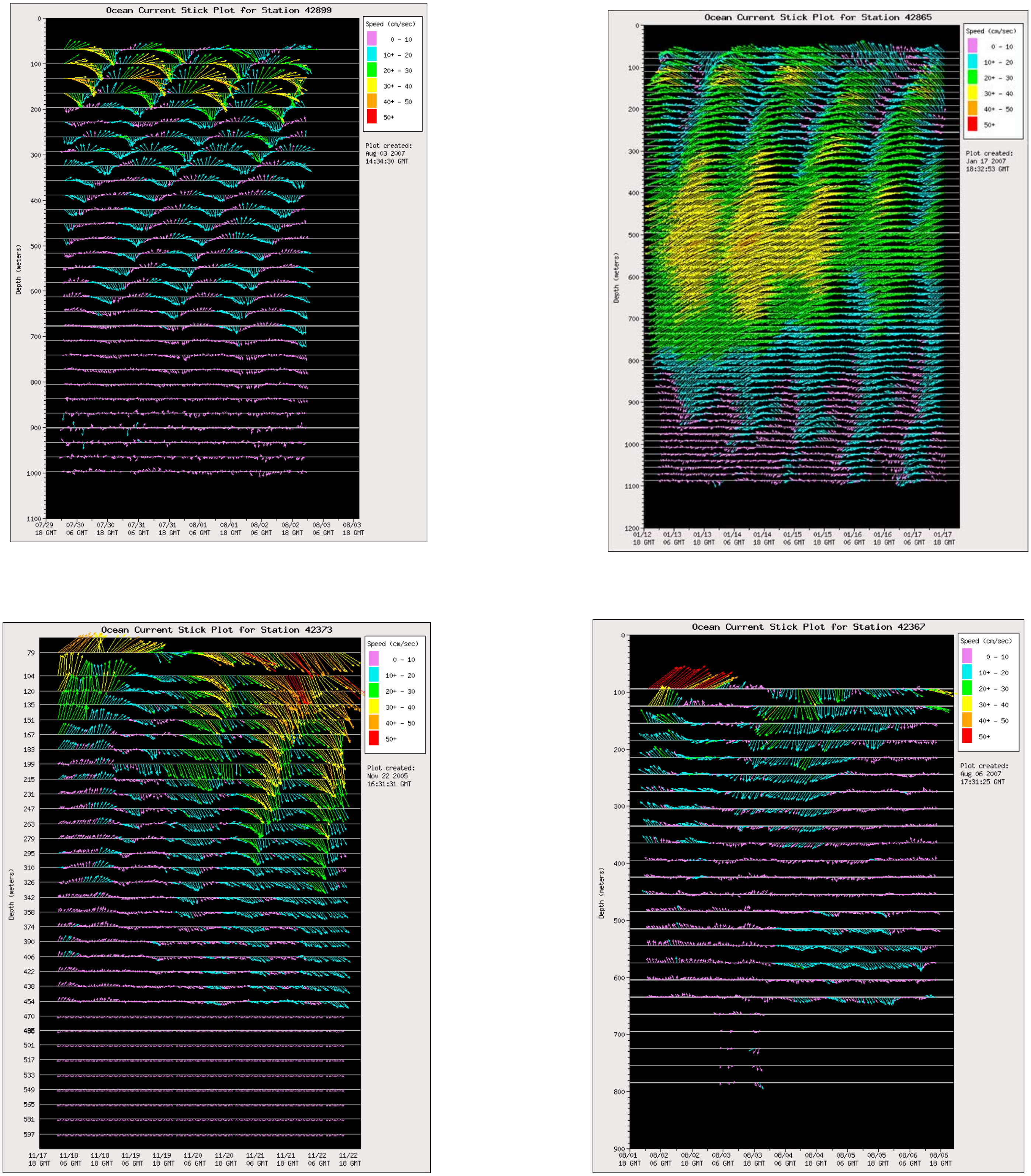

Fig. 1 Four examples of current profiles from oil and gas platforms in the northern Gulf of Mexico showing various ocean phenomena.

The NTL, issued in April 2005 and renewed in April 2007, requires that oil platforms and drilling rigs in water deeper than 400 meters, collect real-time data from near the surface to 1000 meters and report those data every 20 minutes to the NDBC. The data are quality controlled and displayed on the NDBC public website [1]. Additionally, in water deeper than 1100 meters, a bottom-mounted, recording current profiler must be installed and retrieved every three to six months and those data forwarded to NDBC for processing, quality control, and archiving. NDBC began receiving and processing these data in August 2006 and now have approximately eighty-eight bottom current profile data sets. These long-term bottom current profiles provide valuable observations to study ocean phenomena.

II. Background

The Na Kika production platform data are some of the first bottom-mounted Acoustic Doppler Current Profiler (ADCP) data received and processed at NDBC. The platform position to the right of the path Katrina as it moved onto the Louisiana Coast in late August 2005 made it ideal to investigate for any potential impacts from the Hurricane. The Na Kika production platform is located near 28.5^{o}N and 88.24^{o}W in the Mississippi Canyon Block 474 in water approximately 1932 meters deep. The bottom-mounted, upward-looking 75 kHz Teledyne RD Instruments (TRDI) Long Ranger ADCP provided data beginning 18 June 2005 and had a transducer depth of 1930 meters. The ADCP averaged data within 16 meter bins and its range extended to approximately 1415 meters depth.

III. Hurricane Katrina

Data from the surface-mounted ADCP system at Na Kika stopped transmitting at 1754Z 25 August 2005 as Hurricane Katrina was nearing the east Florida coast near Miami. It was removed as Na Kika was evacuated in preparation for the hurricane. As Katrina emerged on the west coast of Florida at 0500 GMT 26 August, the bottom-mounted ADCP at Na Kika recorded near-bottom currents less than 5 cm/s, typical of the area (fig 2). These currents prevailed as Katrina's winds increased from 33 to 46 m/s (65 to 95 knots) on 27 August and then increased to 74.5 m/s (145 knots) by 12 GMT 28 August. Just before 0000 GMT 29 August, the speeds increased to 5 to 10 cm/s towards the south-southeast. Katrina made landfall on the Louisiana Coast at Buras (just north of the mouth of the Mississippi River at 1110 GMT on 29 August and then again on the Mississippi Gulf coast at the Pearl River at 1445 GMT [3].

At Louisiana landfall the currents at Na Kika were directed generally toward the SSE at just over 5 cm/s. After 1300 GMT, the currents diminished to less than 5 cm/s and remained that way until approximately 2100 GMT, when the currents increased, with some speeds exceeding 10 cm/s. Two hours later, most speeds were between 10 and 15 cm/s. By 0120 GMT 30 August, most speeds exceeded 15 cm/s and were toward the ENE. After 0300 GMT, the currents began decreasing until they reached a minimum at approximately 0930 GMT. The currents rotated clockwise from southwestward to northward during the next nine to ten hours when they reached a maximum of 20 cm/s. Speeds decreased over the next five hours and reached a minimum of less then 10 cm/s toward the southeast at approximately 0200 GMT 31 August. During the next six hours speeds increased to greater than 25 cm/s as they rotated toward the west. Minimum speeds on 31 August at approximately 1830 GMT and were approximately 10 cm/s toward the north. The rotation of the currents and alternating high and low speeds continued until 0000 GMT 11 September, although the speeds diminish during the period. The highest speed recorded was 31.5 cm/s toward the southeast at a depth of approximately 1750 meters.

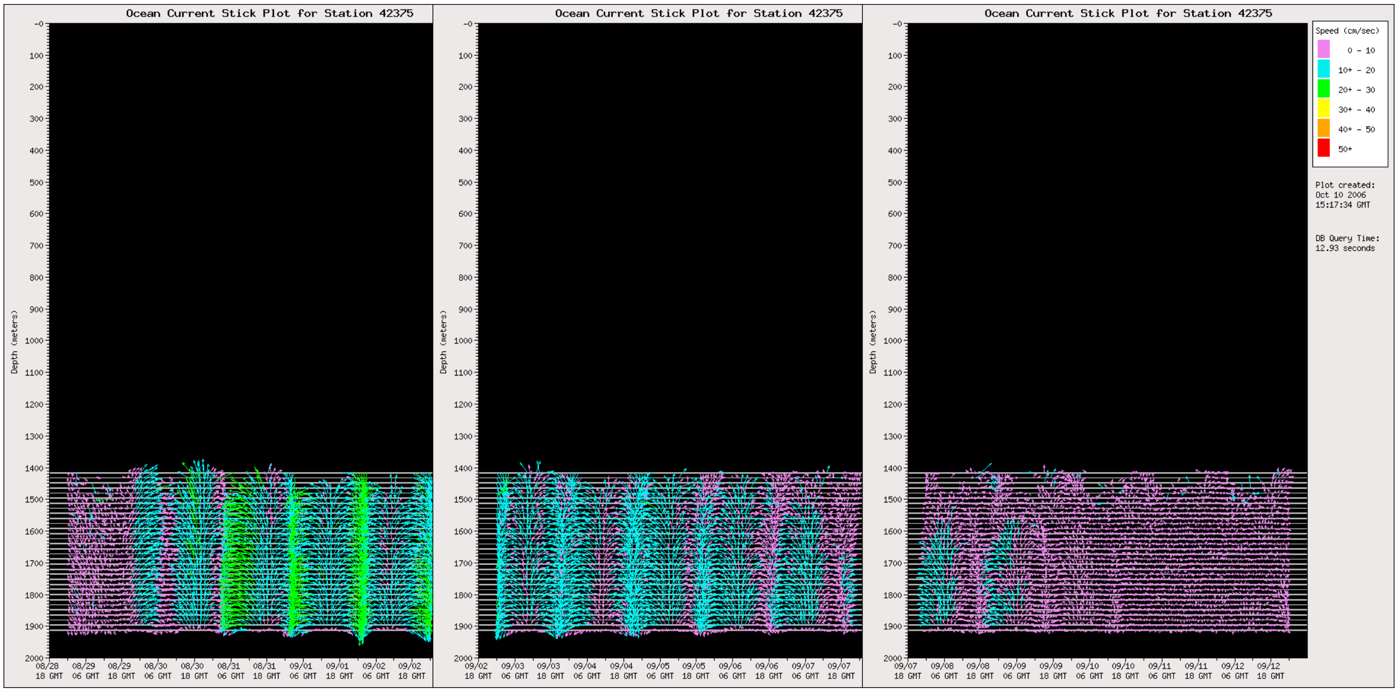

Fig. 2 Bottom currents at Na Kika during and following the passage of Hurricane Katrina.

IV. Hurricane Rita

Hurricane Rita entered the Gulf of Mexico south of Key West in the Straits of Florida about 1200 GMT 20 September, less than one month after Hurricane Katrina. By 1800 GMT 21 September, had attained winds of 74.5 m/s (145 knots). In 36 hours Rita had increased in intensity from a tropical storm to a Category 5 hurricane. Maximum winds were attained at 0300 GMT 22 September when Rita was 485 kilometers south-southeast of the Mississippi River delta. Much of the strengthening occurred as the hurricane passed over the Loop Current in the southeastern Gulf of Mexico [4]. Winds fell as Rita moved west-northwest, then northwest as it crossed the Gulf of Mexico until making landfall near Sabine Pass, Texas 0740 GMT 24 September with winds of 51 m/s (100 knots). At its closest approach to the Na Kika platform, it was approximately 360 kilometers away.

As Hurricane Rita entered the Gulf of Mexico, the currents at Na Kika were less than 8 cm/s in the near-bottom waters. Later on 20 September, currents in excess of 10 cm/s were recorded at depths between 1720 and 1900 meters for a very short time. By 1000 GMT 22 September, most of the currents sampled by the bottom-mounted ADCP were greater than 10 cm/s, indicating an impact by Hurricane Rita. Clockwise rotation of the currents was noted during the next two weeks. The period of the motion was somewhat less than 24 hours. Maximum current speeds during the period of greater than 21 cm/s recorded at 1775 meters depth on 24 September. Much of the energy (higher speeds) was concentrated in the bottom 200 meters of the water column. Speeds in excess of 20 cm/s were measured until mid-morning 28 September.

V. Hurricane Wilma

Hurricane Wilma was spawned in the Caribbean Sea and became a hurricane 18 October 2005. The barometric pressure dropped explosively, dropping 61 millibars in 6 hours and 98 millibars in 24 hours to establish a new Atlantic basin record of 882 millibars at 0600 GMT 19 October. The accompanying category five winds of 82 m/s (160 knots) occurred while the storm was over the Straits of Yucatan. Hurricane Wilma made landfall near Cozumel, Mexico and then emerged into the Gulf of Mexico 0000 GMT 23 October. Before making a second landfall near Cape Romano, Florida at 1030 GMT 24 October, Hurricane Wilma crossed the Loop Current in the extreme southeastern portion of the Gulf of Mexico and attained Category 3 winds of 56.5 m/s (110 knots) [5].

Hurricane Wilma raced across the southeastern portion of the Gulf of Mexico in approximately 36 hours. At its closest approach to the Na Kika platform, it was about 600 kilometers distant. Currents at Na Kika were generally less than 5 cm/s until approximately 1400 GMT 26 October. Some speeds exceeded 10 cm/s and they were generally at depths less than 1575 meters

depth. The currents rotated with time and varied from less than 5 cm/s to 12 cm/s. Maximum speeds of greater than 20 cm/s at Na Kika were recorded at 0845 28 October. The currents were toward the southeast and did not extend the bottom. The record continued to show influence from Hurricane Wilma until 8 November.

VI. Discussion

Data collected by bottom-mounted ADCPs installed by the oil and gas industry in the Northern Gulf of Mexico reveals surprising characteristics of near-bottom currents. Background current speeds within 500 meters of the bottom appear to be generally less than 5 cm/s. However, the energy from hurricanes in the Gulf of Mexico is transported over kilometers horizontally and almost two kilometers vertically to have a relatively large and long-lasting effect on bottom currents. While the highest currents (30 cm/s) were recorded in response to Hurricane Katrina as it passed less than 120 kilometers away, currents in excess of 20 cm/s were recorded in response to both Hurricanes Rita and Wilma, which were never closer than about 350 kilometers away. The long-lasting impact of these storms, from 10 to 14 days, is also apparent from the data collected by these platforms.

The quality, length of record, relatively high vertical resolution of the data, and extremely high temporal resolution of the data (10 to 20 minutes) allow for high quality research into various ocean phenomena. The importance of these observations as "ocean truth" for ocean modeling is obvious.

VII. Summary

In addition to quality controlled, surface-mounted current profile data from more than 60 oil platforms in the northern Gulf of Mexico, more than eighty, quality controlled, near-bottom current profile records are available for analysis from NDBC. Both data sets are stored in binary format and in ascii format with the quality flags attached. These data often contain rarely measured phenomena from deep in the Gulf of Mexico. The response of one location in the northern Gulf of Mexico is present here. The dynamics of the ocean in response to hurricanes is a popular topic that these data will support in the future.

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